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NATIONAL TRANSPORTATION SAFETY BOARD

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STRUCTURES GROUP CHAIRMAN'S FACTUAL REPORT

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NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594
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Group Chairman's Factual Report

STRUCTURES

DCA18MA142

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A. Structures Group

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B. Summary

On April 17, 2018, at 1103 eastern daylight time, Southwest Airlines flight 1380, a Boeing 737-700, N772SW, experienced a left engine failure and loss of engine inlet and cowling during climb at about flight level 320. Fragments from the engine inlet and cowling struck the wing and fuselage resulting in the failure of one cabin window and cabin depressurization. The flight crew conducted an emergency descent and diverted into Philadelphia International Airport (KPHL), Philadelphia, PA. Of the 144 passengers and five crewmembers onboard, one passenger received fatal injuries and eight passengers received minor injuries. The airplane sustained substantial damage. The regularly scheduled domestic passenger flight was operating under 14 Code of Federal Regulations Part 121 from LaGuardia Airport (KLGA), Queens, New York, to Dallas Love Field (KDAL), Dallas, Texas.

This is the preliminary Structures Factual Report documenting the on-scene airplane structural damage.

C. Details of the Investigation

1.0 Airplane Description

Registration Number:	N772SW
Airplane Serial Number:	27880
Airplane Manufacturer:	Boeing
Model:	737-700 (7H4)
Engine Manufacturer:	CFM International
Model:	CFM56 Series
Airplane Year:	2000
Airworthiness Certificate:	Standard
Approved Operations:	121
Aircraft Type:	Fixed Wing Multi-Engine
Engine Type:	Turbo Fan
Airplane Category:	Transport
Number of Engines:	2
Max. T/O Weight:	154,500 pounds
Total Time:	63,043 hours
Total Cycles:	36,728
Type Certificate	A16WE Revision 61
Wing span (all versions):	112 ft 7in
Wing span (with winglets):	117 ft 5 in
Wing chord at the root:	18 ft 9 in
Wing chord at the tip:	4 ft 1 1/4 in
Overall length (700):	110 ft 4 in
Overall height (700):	41 ft 3 in
Engine centerline distance:	31 ft 8 in

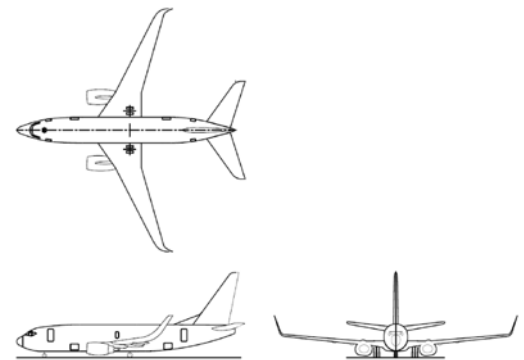


Figure 1 – 737 three view

The 737-700 NG is a conventional, medium-sized airliner with underwing engines and a sweptback wing. The fuselage is a semi-monocoque structure. Much of the primary structure in the fuselage is manufactured from high strength aluminum alloys. The passenger compartment windows are located between the fuselage frames and stringers/longerons in the passenger compartment.

The current “Next-Generation” (NG) family (initially 737X) originated in 1991. The CFM56-7B power plant first flew on Boeing the 747 testbed on 16 January 1996.

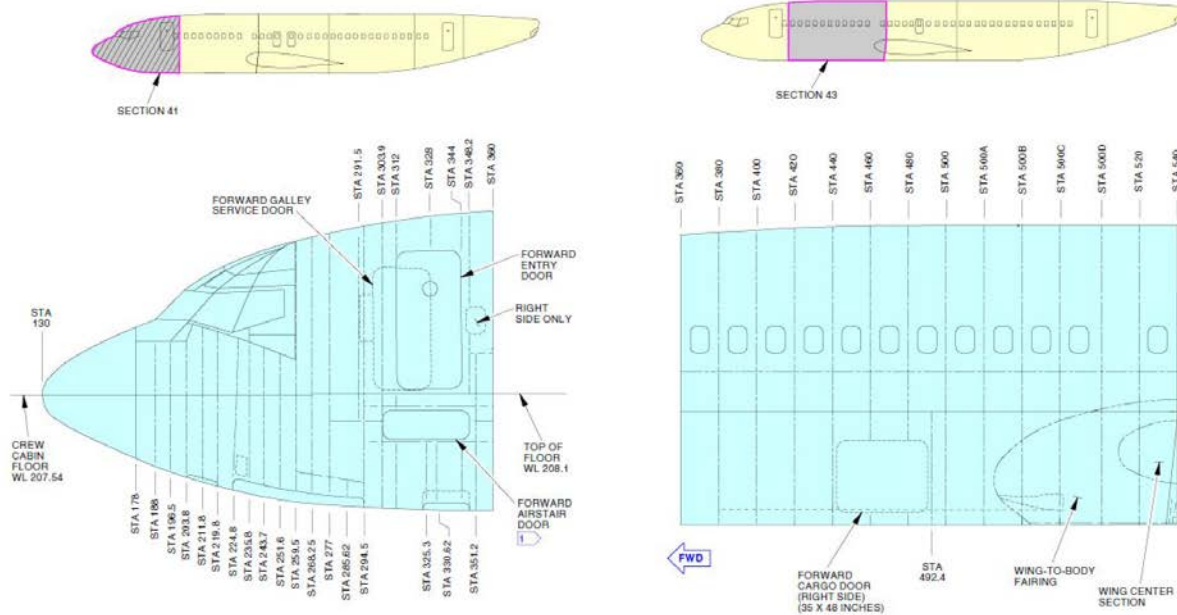


Figure 2 – Forward fuselage stations

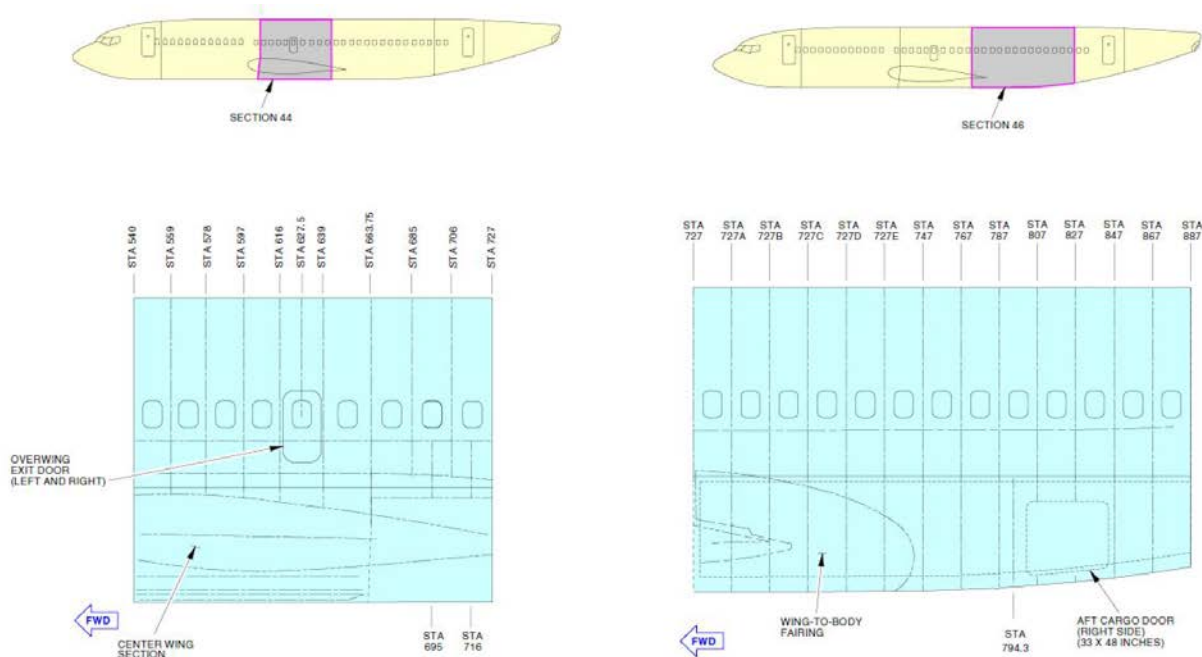


Figure 3 – Mid and aft fuselage stations

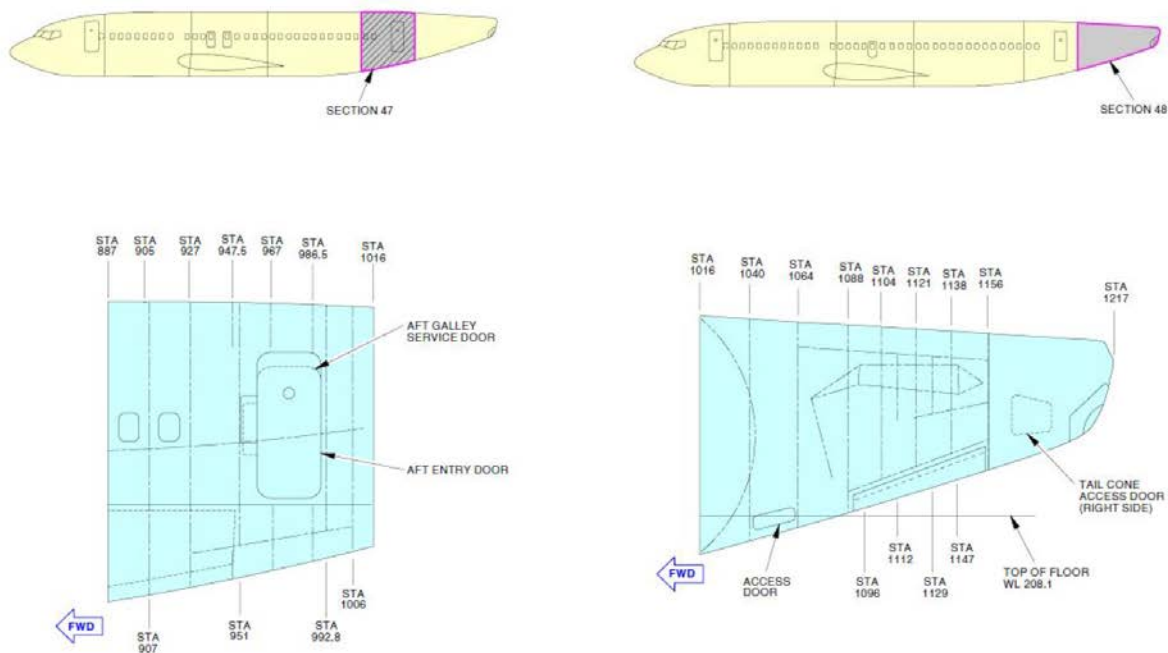


Figure 4 - Aft fuselage stations

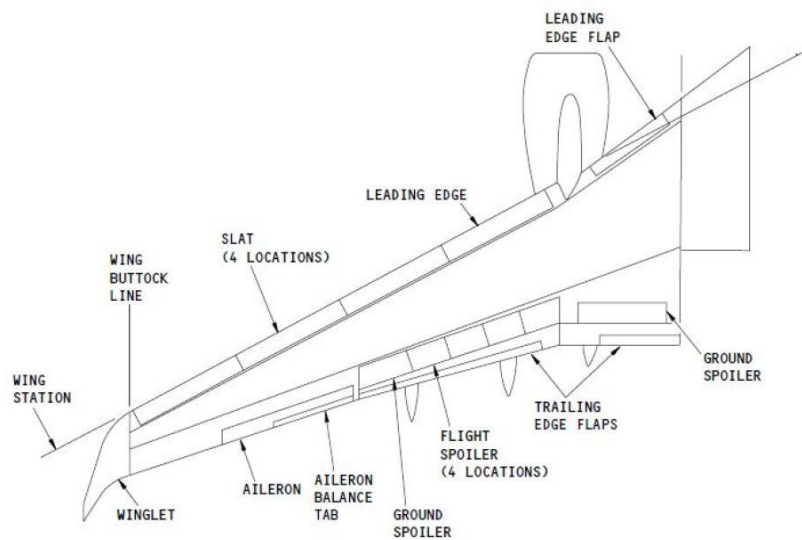


Figure 5 - Wing structural components

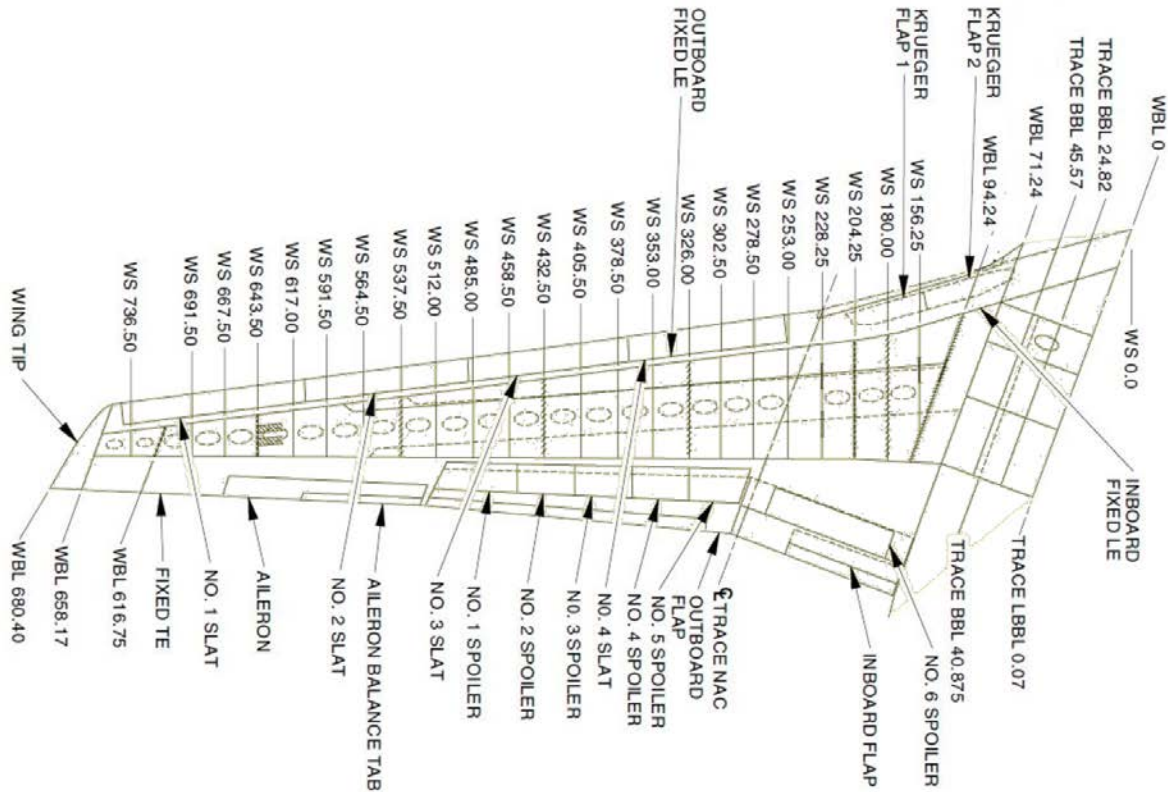


Figure 6 – Wing stations

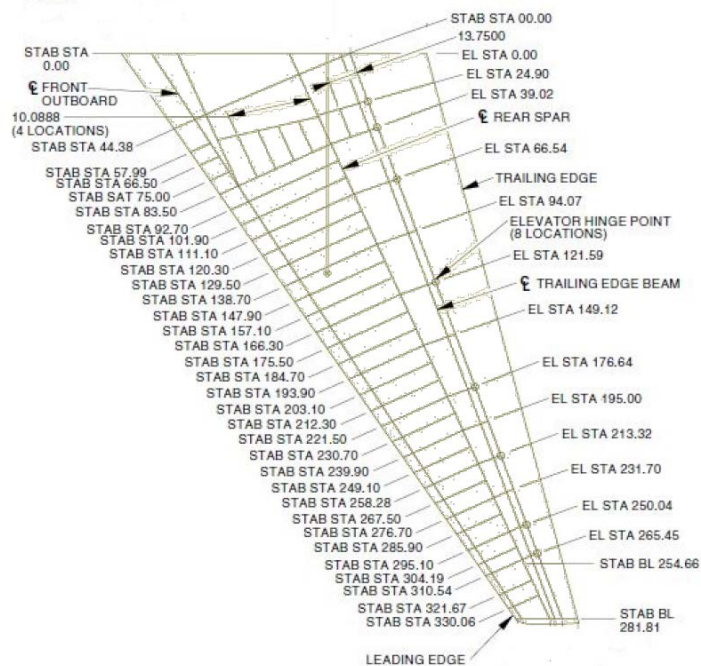


Figure 7 – Horizontal stabilizer stations

2.0 Recovered Airplane Debris

On April 19, 2018, the Federal Bureau of Investigation (FBI) assisted by the NTSB staff conducted a physical search of the vicinity of Bernville, Pennsylvania (PA) for parts of Southwest Airlines flight 1380.

Parts of the aircraft were found at four separate locations. The parts recovered were documented according to the site where they were initially located.

Site 1 was defined as the property owned by the Pennsylvania Game Commission, located at State Game Land #280, North Section, off Bernville Road near the intersection with Bright School Road, Bernville, PA. See Figures 8 thru 13.



Figure 8 – Outer Barrel, Part 1 Site 1(P1S1)

Part 1 Site 1 (P1S1) was found in place and recovered by two Pennsylvania Game Commission employees. The part was placed in storage and the location had been marked. The piece was reported as being found with the painted side facing upwards, and the control arm submerged into the ground approximately four inches. It was located at 40.4192790, 76.0904399. See Figure 8.

Part 2 Site 1 (P2S1) was a small piece of silver-colored metal. The part was found by the property owner on his property in Lenhartsville, PA. It was placed in an envelope by the property owner and provided to FBI. The property owner indicated that he located the item approximately one meter from his front door. NTSB staff subsequently determined it was not a part of the aircraft. No photograph of the was part taken.



Figure 9 – Fan Cowl Frame, Part 3 Site 1 (P3S1)

Part 3 Site 1 (P3S1) was recovered in the tree line which separates the 9th and 16th fairways of the Heidelberg Country Club, 1 Club House Drive, Bernville, PA. The part was located at 40.42605833, 76.12555556. See Figure 9.

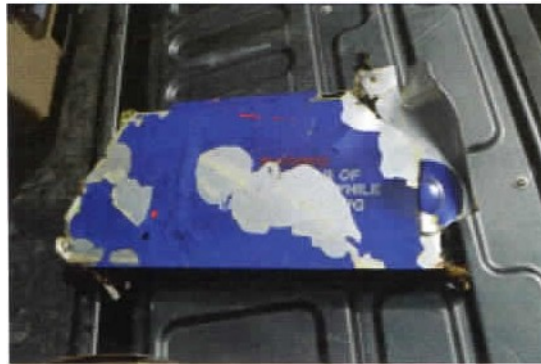


Figure 10 – Section of the Inboard Fan Cowl, Part 4 Site 1 (P4S1)

Part 4 Site 1 (P4S1) was recovered on the woman's tee of the 17th hole of the Heidelberg Country Club, 1 Club House Drive, Bernville, PA. The part was located at 40.42888889, 76.12833333. See Figure 10.

Both cowling parts 3 and 4 were located at the golf course described above and delivered to site one.



Figure 11 - Fan Cowl, Part 5 Site 1 (P5S1)

Part 5 Site 1 (P5S1) was recovered in place and located at 40.4197168, 76.0924710. See Figure 11.



Figure 12 – Fan Cowl, Part 6 Site 1 (P6S1)

Part 6 Site 1 (P6S1) was recovered in place and located at 40.4192145, 76.0906424. See Figure 12.



Figure 13 – Fan Cowl, Part 7 Site 1 (P7S1)

Part 7 Site 1 (P7S1) was recovered in a wooded area in place and located at 40.4197224, 76.00876859. See Figure 13.

Site 2 was located near 693 Christmas Village Road 1 in Bernville, PA. All the parts recovered at Site 2 were within approximately ten feet of each other. See Figures 14 thru 18.



Figure 14 - Upper D-Duct, Part 1 Site 2 (P1S2)

Part 1 Site 2 (P1S2) was recovered in place and located at 40.421134, 76.1597123. See Figure 14.



Figure 15 – Upper Outer Barrel, Part 2 Site 2 (P2S2)

Part 2 Site 2 (P2S2) was recovered in place and located at 40.421134, 76.1597123. See Figure 15.



Figure 16 – Metallic and honeycomb part, Part 3 Site 2 (P3S2)

Part 3 Site 2 (P3S2) was recovered in place and located at 40.421134, 76.1597123. See Figure 16.



Figure 17 – Metallic honeycomb, Part 4 Site 2 (P4S2)

Part 4 Site 2 was recovered in place and located at 40.421134, 76.1597123. See Figure 17.



Figure 18 – Honeycomb, Part 5 Site 2(P5S2)

Part 5 Site 2 (P5S2) was recovered in place and located at 40.421134, 76.1597123. See Figure 18.

Part 6 Site 2 (P6S2) was comprised of multiple small parts and paint chips were recovered in place and located at 40.421134, 76.1597123. No photograph was taken of the parts.

Site 3 was located on Batdorf Road near the intersection with Hetrick Road, Bernville, PA. See Figure 19.



Figure 19 – Lower D-Duct and Outer Barrel, Part 1 Site 3 (P1S3)

Part 1 Site 3 (P1S3) was recovered in place and located at 40.424090, 76.1657070. A local resident notified authorities of the location of the part. See Figure 19.

Site 4 was defined as the property located across the street from 392 Batdorf Road, Bernville, PA. See Figure 20.



Figure 20 – Aft Bulkhead Section, Part 1 Site 4 (P1S4)

Part 1 Site 4 (P1S4) was recovered in place and located at 40.39528, 76.1341108. The property owner notified the authorities of the location of the part. See Figure 20.

3.0 Damage to the Airplane Structure

The airplanes left hand side fuselage, wing leading edges, wing upper and lower surfaces and the horizontal stabilizer exhibited evidence of impact damage along with blue and red paint transfers. The impact damage consisted of surface scratching, skin gouging and skin penetrations.



Figure 21 – Overview of wing and inlet damage

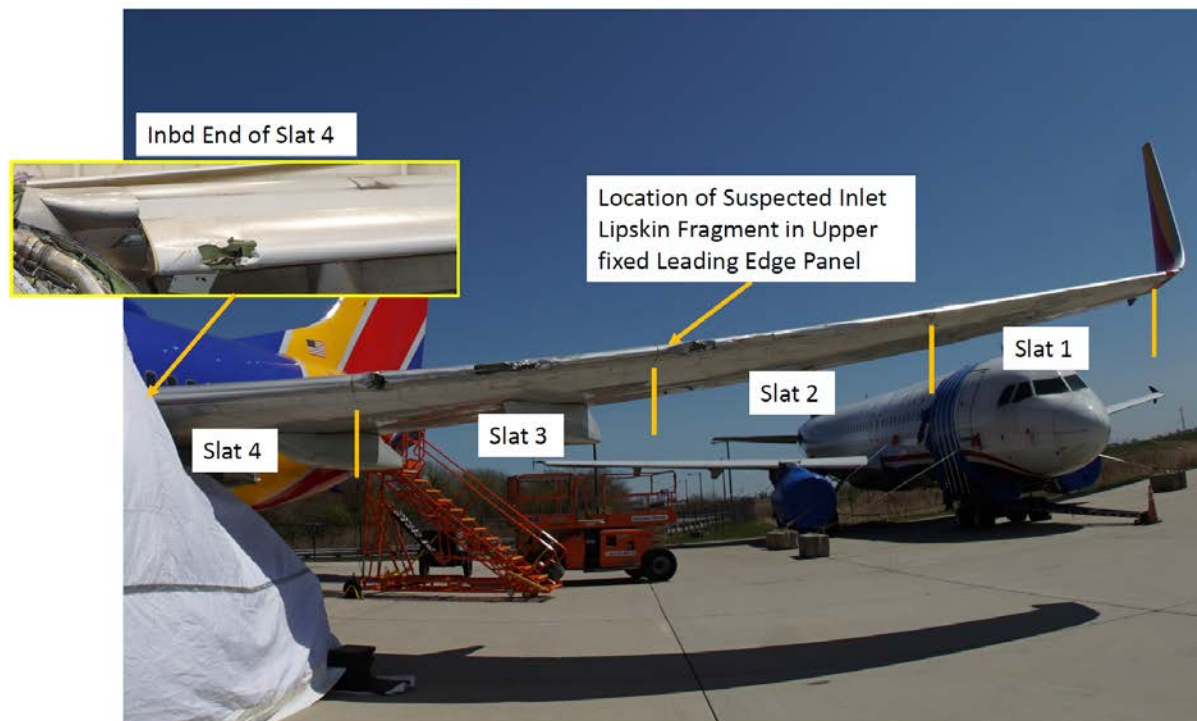


Figure 22 - Wing leading edge damage



Figure 23 - Outboard wing upper surface damage

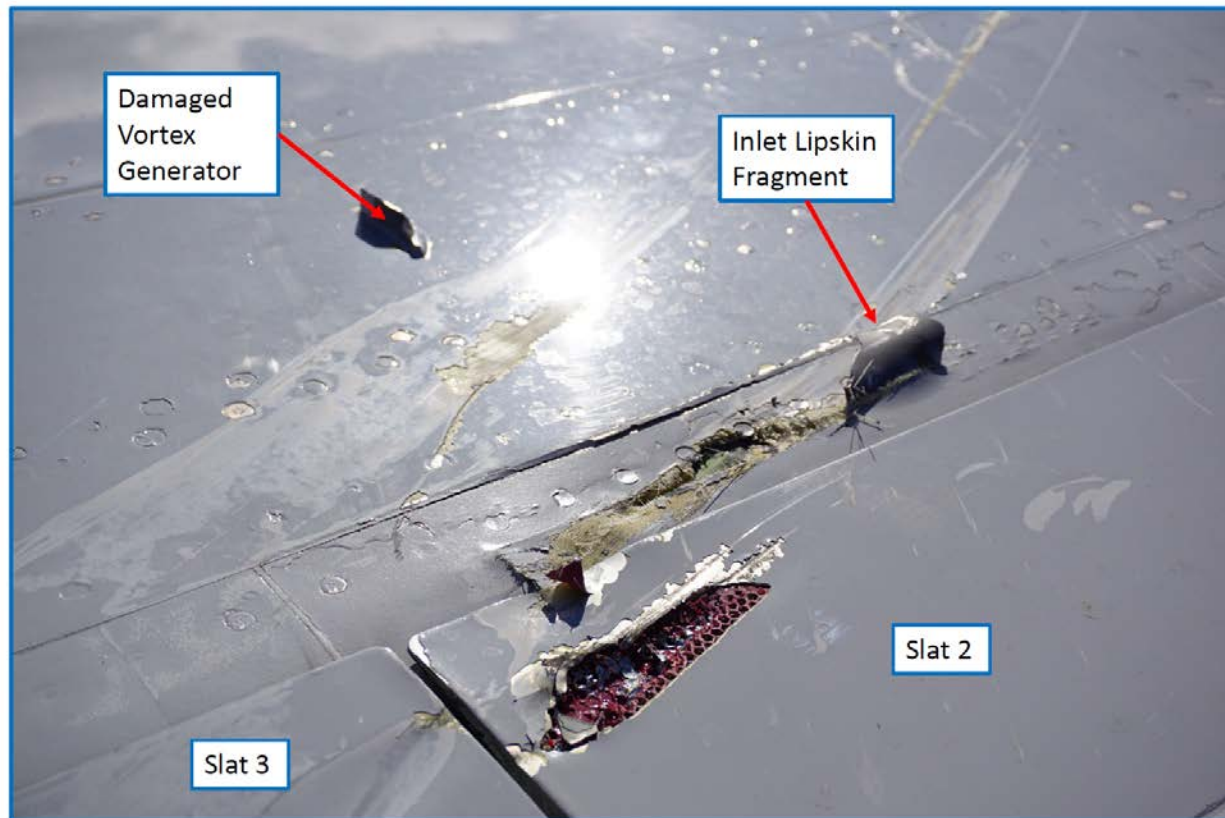


Figure 24 – Inlet fragment detail



Figure 25 – Wing leading edge damage



Figure 26 – Wing leading edge damage



Figure 27 – Wing lower surface damage



Figure 28 - Wing upper surface damage



Figure 29 – Horizontal stabilizer damage

4.0 Passenger Window Assembly & Associated Fuselage Damage

The passenger window assembly consists of an outer pane and middle pane held together by a silicon rubber seal. The outer panes are made from stretched acrylic and the middle pane is either made from cast acrylic or stretched acrylic depending on the version of the window. The 737 outer panes were qualified by test in 1967. They were designed to meet the requirements of 14 CFR 25.775(d). There are no FAA or Boeing design requirements regarding impact resistance for passenger windows. There are no directed inspections for passenger windows.

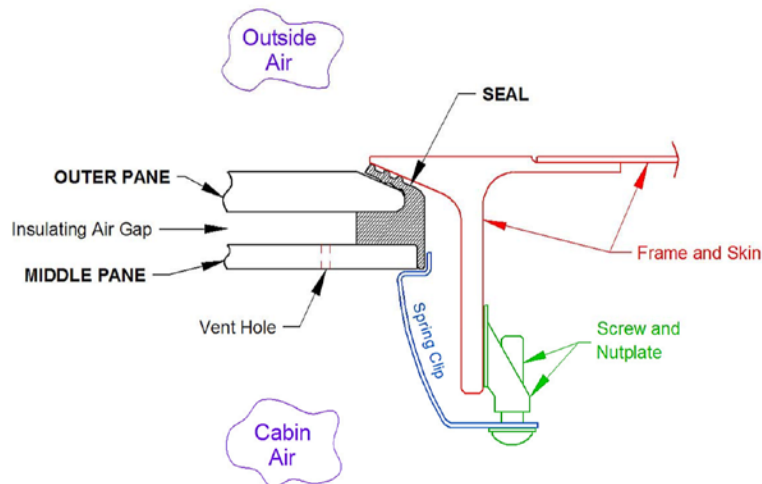


Figure 30 - Passenger window assembly

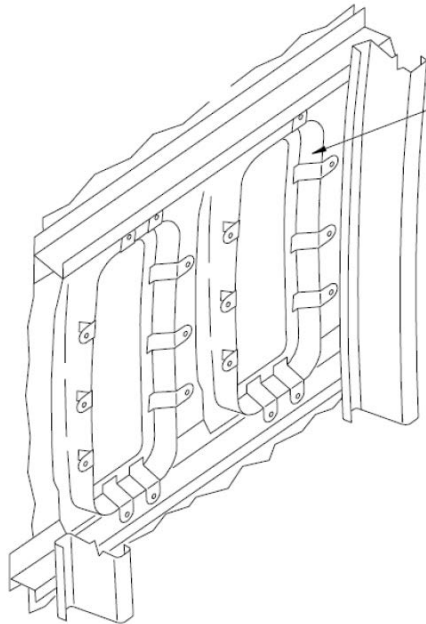


Figure 31 – Passenger window interior view schematic

None of the window inner and outer panes or the seal were recovered from inside the airplane or during the ground recovery of airplane debris. The cowling structure that impacted the fuselage caused a small puncture to the fuselage skin just below the incident passenger window.

This was the first known complete passenger window loss event in 737 fleet history. There has been a total of 29 outer pane fracture events in the 737 fleet and 16 events in the 757 fleet (same passenger window part number). In all cases, the middle panes performed as designed and the carried the applied pressure load.

In addition to the N772SW event, Boeing is aware of 8 other complete passenger window loss events; one to a 707, three to 727 models, and four on 747 models. Seven of those events were either on cargo aircraft or empty airplanes, with no reported injuries. The eighth event involved a 747-passenger window that departed at 12,500 feet. There was no passenger in the adjacent seat and no reported injuries.



Figure 32 – Interior fuselage impact damage¹

¹ The interior non-structural side wall panels were removed in order to access the backside of the fuselage skin.

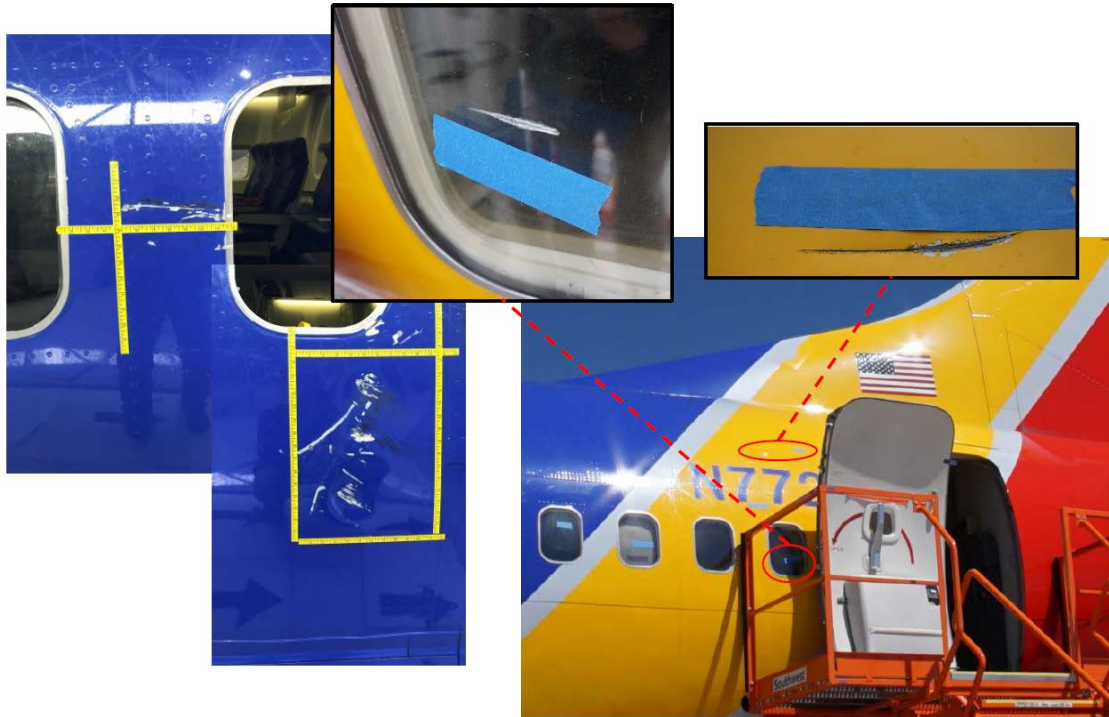


Figure 33 - Exterior fuselage impact damage

The lower aft corner of a portion of the inboard fan cowl that departed the airplane was compared to the fuselage damage between fuselage stations 700 to 727, and stringers 12 left to 15 left. The lower aft most corner of the inboard fan cowl exhibited evidence of impact damage. The fuselage skin below the window just above stringer 14 left also exhibited evidence of impact damage. There were additional witness marks in the fuselage skin just forward of the window at about stringer 12 left.



Figure 34 – Fan cowl to fuselage witness mark comparison



Figure 35 – Detailed witness mark comparison



Figure 36 – Fuselage skin damage at stringer 12L



Figure 37 - Lower corner fuselage to fan cowl section witness mark comparison



Figure 38 – Lower passenger window impact damage detail



Figure 39 – Figure 38 impact damage to fan cowl section comparison



Figure 40 – Figure 39 detail view



Figure 41 – Separated fan cowl structure

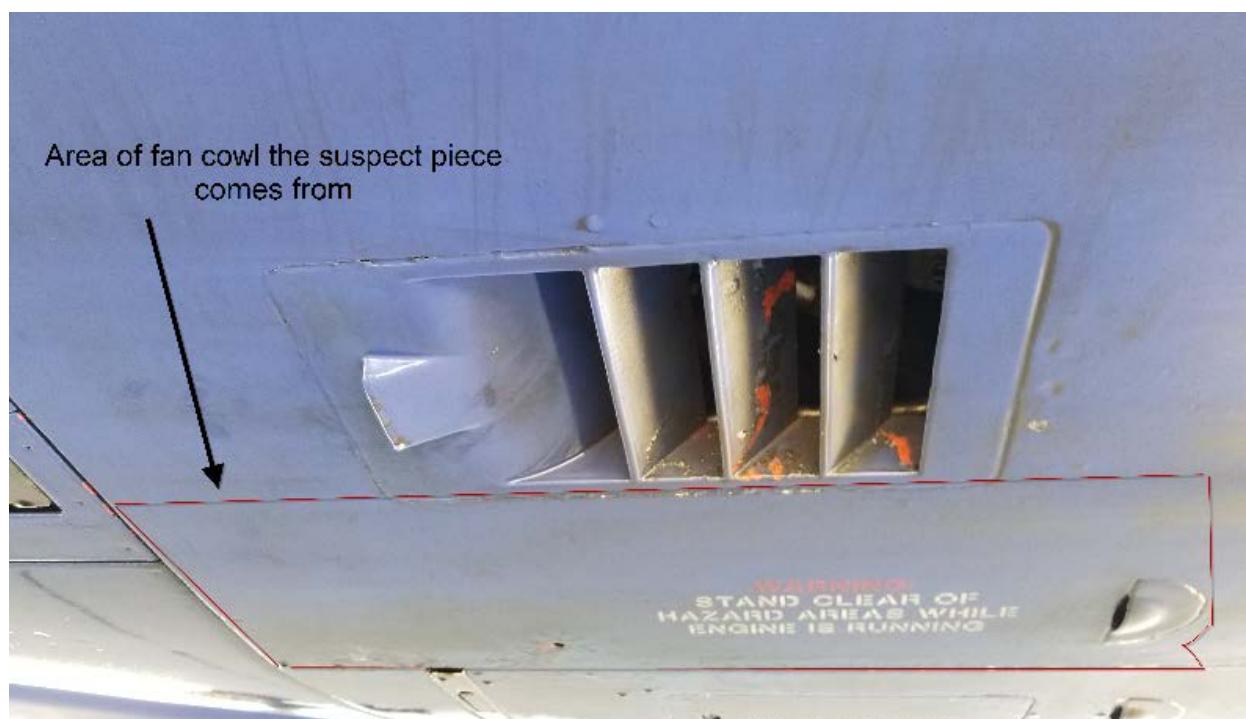


Figure 42 – Exemplar location of the separated fan cowl structure

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